Generation X Study

Thermal

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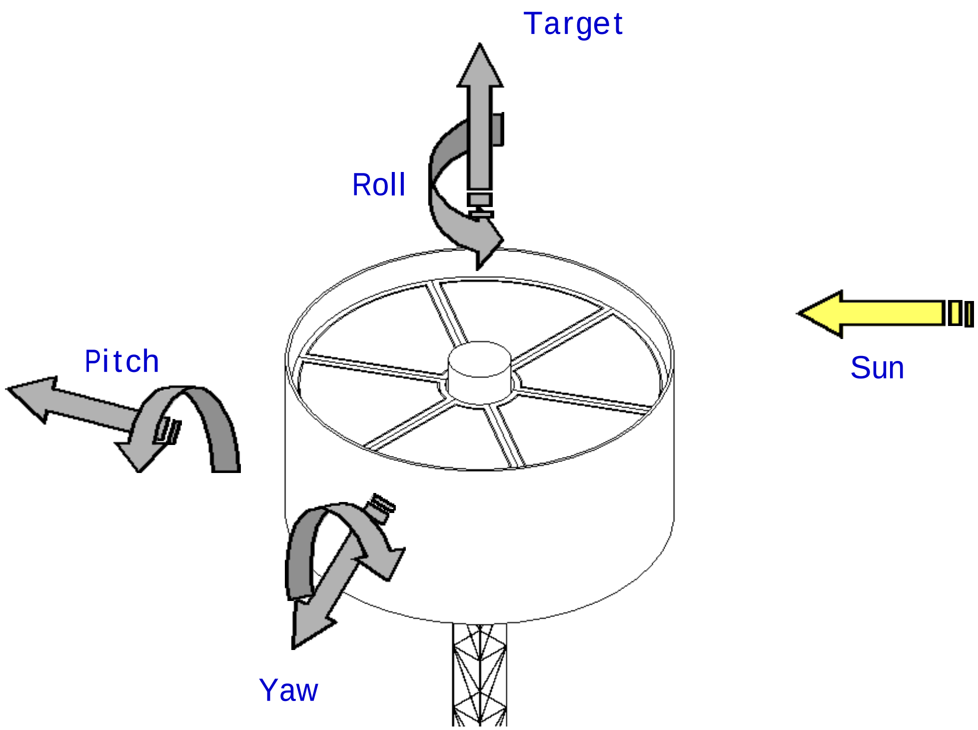
Requirements

- **Collectors**
  - Aperture consists of many 0.3 mil thick glass segments with 8 mil radial separation and 1m axial length in various configurations:
    - deployed "petals"
    - 6m OD with 1m ID bus
    - Two 4m OD
  - maintain at ambient temperature, with ~1°C gradient across/through mirror segments
  - ~5000kg mass estimate!!
- **FPA**
  - end of ~100m Astro Mast
  - Cry-cooler requires 75°K (or better) sink to achieve < 1°mK detector
  - possible housekeeping (power, RF data link to SC, propulsion)
  - 50kg mass estimate
- **SC bus**
  - Assess spinner versus fixed

Thermal Environment (Attitudes)

- ♦ **Roll**
  - Fixed: R = 0°
  - optional: 0° < R < 360° at 1rpm
- ♦ **Pitch**
  - 0° < R < 360°
  - during target acquisition
- ♦ **Yaw**
  - -15° < Y < +15°



Collector/Bus Configurations

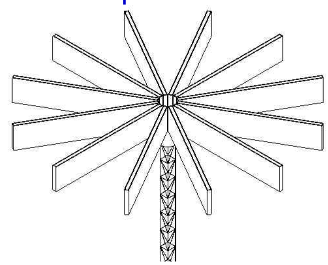
♦ Option 1, 2, & 3

- Requires ~1rpm roll or complex heat transport system
- Spinner:
  - De-spun bus/core
  - Momentum unloading for target acquisition pitch maneuvers

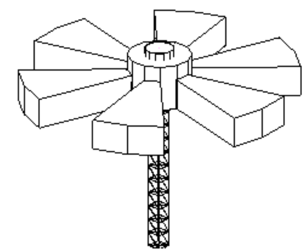
♦ Option 4

- SA serves as sun shield
- No spinner
- No heat transport system to spread sun-side heat

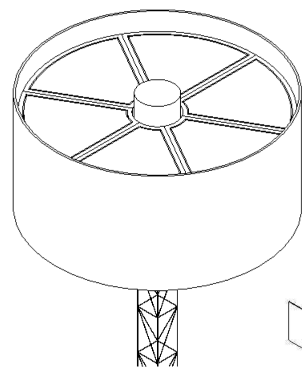
Option 1



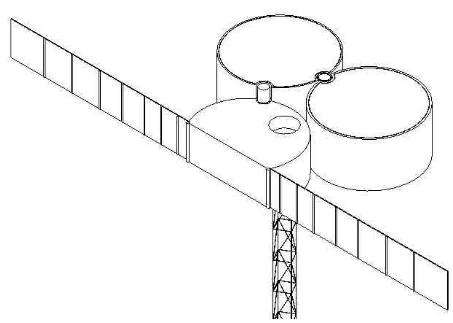
Option 2



Option 3



Option 4



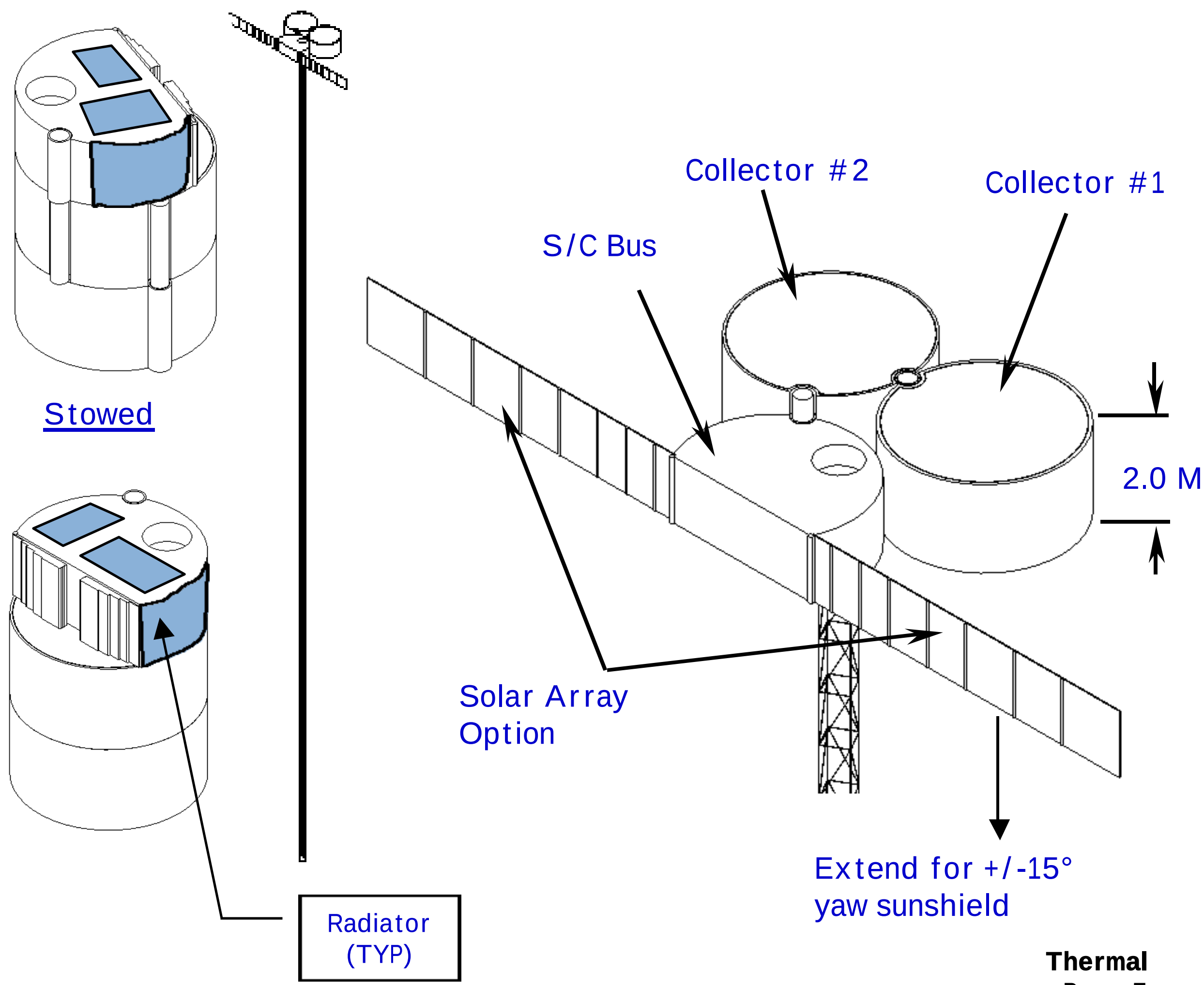
Most Promising Concept

Option #4

- Direct insertion to L2
- Delta IV launch vehicle
    - mass critical !!
- 3 Modules
    - 2 collectors 4M dia. each
    - 1 bus 4M dia.
- Modules will rotate and drop into place
- Solar array
    - deployed from side of bus
    - along surface of collectors
- Mast deploys to 100 M

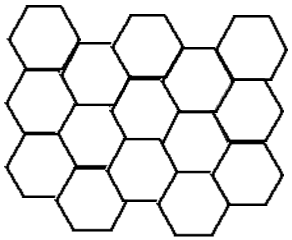
Draw-backs:

- Mass Critical
- If shuttle is used no provisions have been made for apogee kick motor for L2 insertion



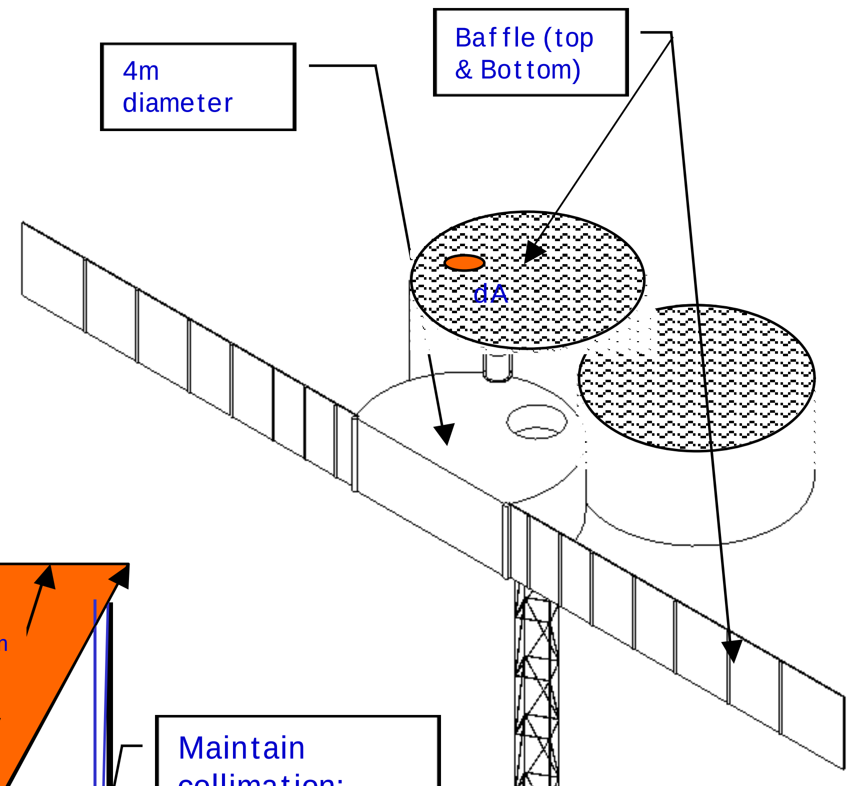
Collector(s)

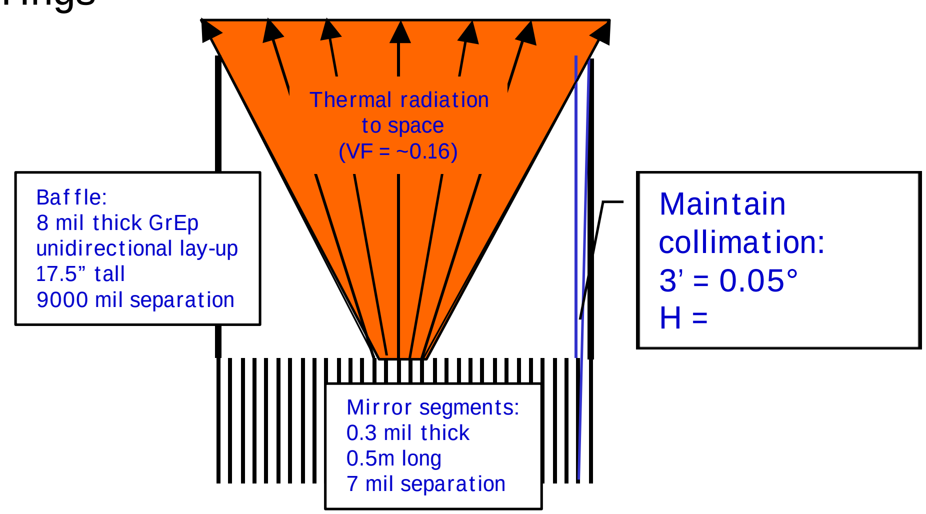
- **Determine area averaged emissivity for telescope aperture:**
  - ε = 0.70 (mirror edge) and ε = 0.03 (gold)
  - Edge fraction <5% of aperture area
  - $\varepsilon_{effective}$ = 0.044
- **Maintain at ambient temperature (20°C)**
  - Large amount of heater power without baffle:
    - 1000W (6 m aperture)
    - 900W (two 4m apertures)
- **Baffles must maintain 3' collimation angle to bottom of mirror segment**
  - Height is a function of radial separation
  - Anisotropic material (GrEP, Kevlar, etc) : $K_{circ} \gg K_{axial}$
  - Concepts:
    - Concentric rings
    - Honeycomb
    - Variable coatings



Collector Baffle

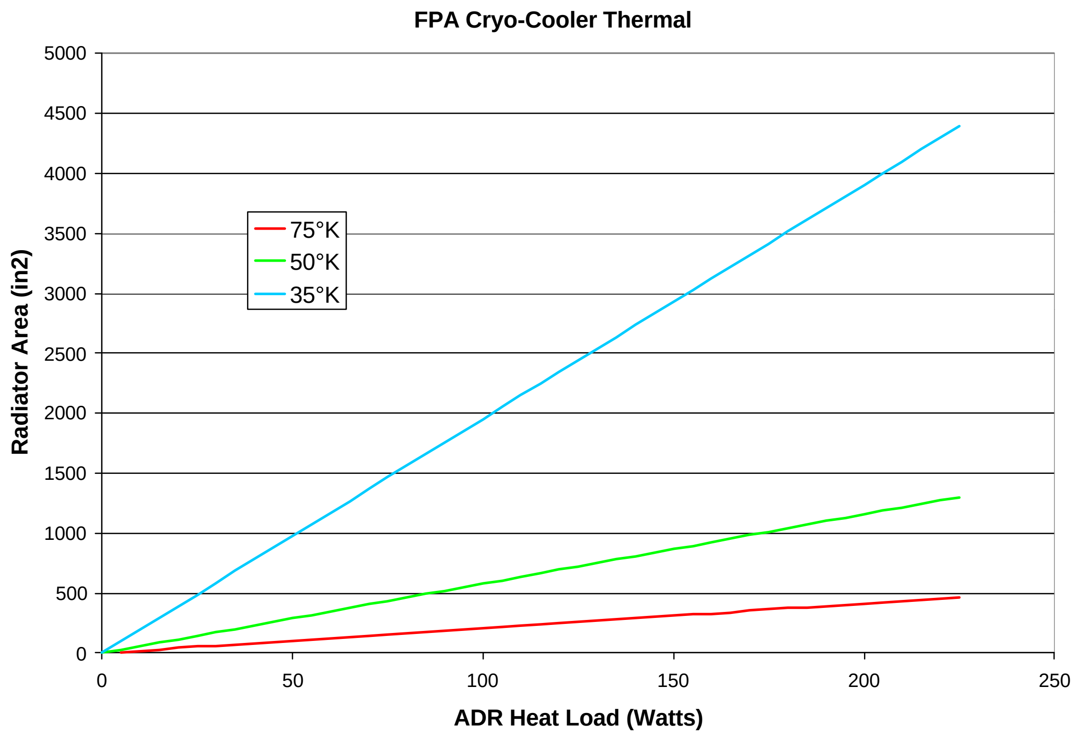
- **Baffles must maintain 3' collimation angle to mirror segment**
  - Height is a function of radial separation of baffle "vanes"
  - Anisotropic material (GrEP, Kevlar, etc) : $K_{circ} \gg K_{axial}$
  - Concepts:
    - Concentric rings
    - Honeycomb





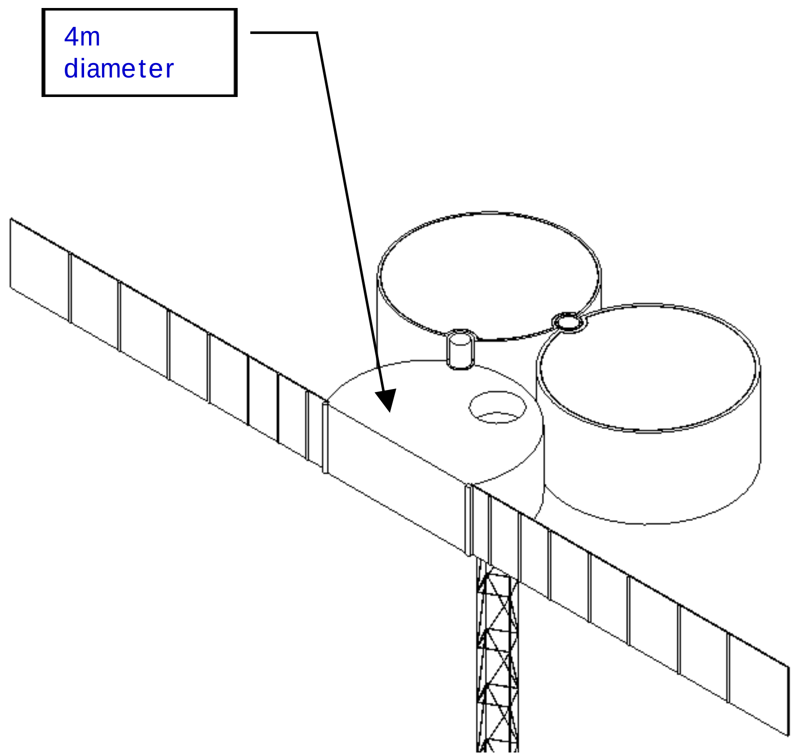
FPA Thermal Control

- ♦ **Size passive radiator for FPA cryo-cooler to 35°K to 75°K.**
- ♦ **Minimize cabling along mast:**
  - Local solar array
  - RF link to SC
  - Local propulsion



Housekeeping Bus

- Circular cylinder shown; likely would be faceted; i.e. octagon, etc.
- Radiator area (usable):
  - ~15m^2 top & bottom
  - ~2m^2 side
- Component mounting:
  - top and bottom panels of bus compartment
  - sides panels
- Thermal control
  - not power limited
  - heat pipe spreaders, if needed
  - heaters, TT, TS, MLI, coatings



Thermal Hardware Costs

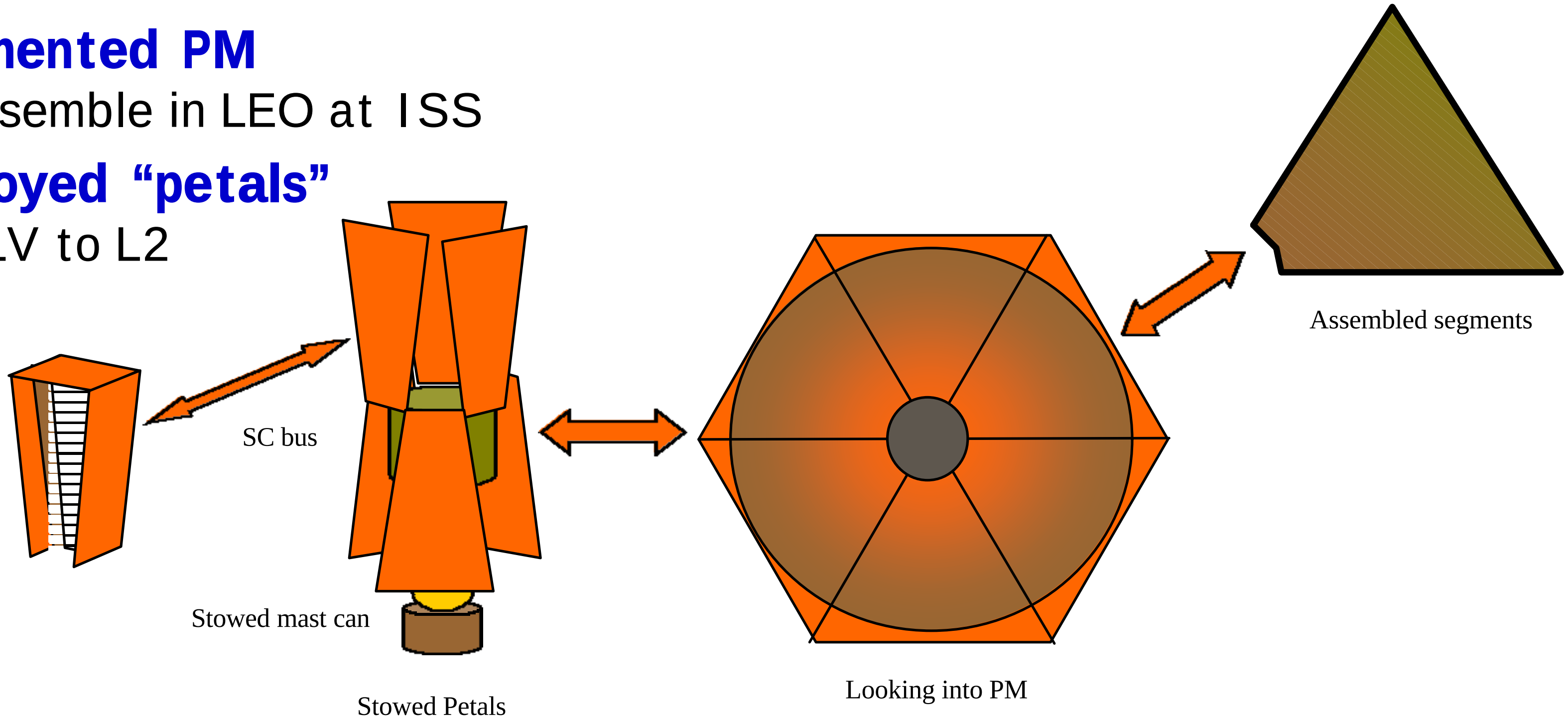
No.	Component Name	Maturity	Quantity	Cost ($K)	Mass (kg)	Power(W) (Orbit Avg)
1	Heat Pipes (NH3)		8	80	8	
2	Heat Pipe Radiator Panel (1 sqm)		3	360	15	
3	Thermofoil Heaters	NASA S311-P-079	50	4	1	1000
4	Multi Layer Thermal Insulation		1 set	100	10	
5	paint/coatings		1 set	50	2	
6	Proportional Temperature Controller		10	20	2	15
7	Thermistors	NASA S311-P-041	80	8	0	
8	Thermostats	NASA S311-P-041	80	32	1	
9	Sunshield for FPA		1	50	3	

The END !!!!

[except for Back-Up Slides]

Configurations Considered

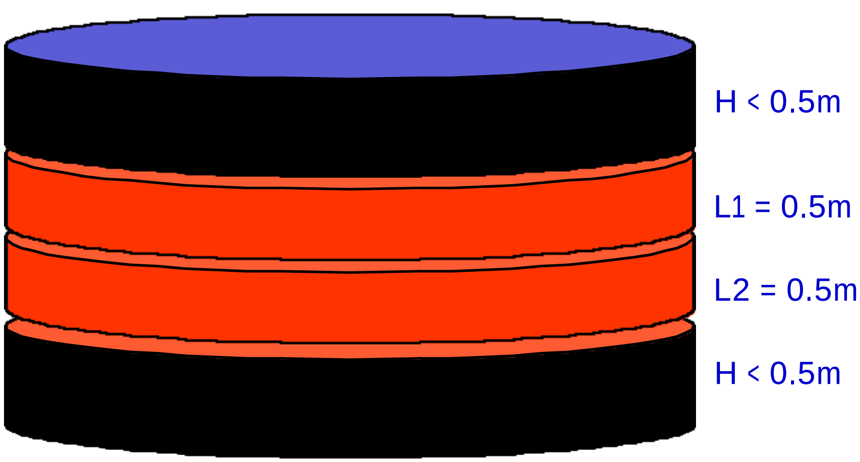
- ♦ **Segmented PM**
  - assemble in LEO at ISS
- ♦ **Deployed "petals"**
  - ELV to L2



- ♦ **Spinners vs fixed**
  - fixed may require spreading of radial heat load from sunside of PM, unless a sunshield can be deployed (a la NGST)
  - spinner would cancel this effect by integrating sun over entire PM

PM Thermal Control

- **Thermal shield/baffle/collimator needed for PM to reduce heater power for ambient temperature control (applies to all configurations).**
  - Conductive control approach will induce gradients >> 1°C
  - Radiative control best option to (try to) meet 1°C gradient.



Thermal baffle
Height varies with radial separation to maintain 3' collimation angle:
use 1.00" separation ==> < 20" height
100mil thick GrEp (uni-directional)

Gen X Configuration